

CLAIMS

What is claimed is:

1. An optical switching system comprising:
 - a. a first waveguide emitting a first beam;
 - b. a second waveguide emitting a second beam;
 - c. a third waveguide;
 - d. a fourth waveguide;
 - e. a first bi-stable mirror deflecting the first beam toward the third waveguide in a first switch position and toward the fourth waveguide in a second switch position; and
 - f. a second bi-stable mirror deflecting the second beam toward the third waveguide in the second switch position and toward the fourth waveguide in the first switch position.
2. The optical switching system of claim 1, wherein the first beam is an input beam and the second beam is an add beam.
3. The optical switching system of claim 1, wherein the first and second bi-stable mirrors are members of an array of bi-stable mirror pairs.
4. The optical switching system of claim 1, wherein the array is two-dimensional.
5. The optical switching system of claim 1, further comprising a mirror disposed in the paths of the first and second beams between the first bi-stable mirror and the second bi-stable mirror.

6. The optical switching system of claim 1, further comprising:
 - a. a third bi-stable mirror; and
 - b. a fourth bi-stable mirror;
 - c. wherein the third bi-stable mirror deflects the first beam from the first bi-stable mirror to the third waveguide in the first switch position and deflects the second beam from the second bi-stable mirror to the third waveguide in the second switch position; and
 - d. wherein the fourth bi-stable mirror deflects the second beam from the second bi-stable mirror to the fourth waveguide in the first switch position and deflects the first beam from the first bi-stable mirror to the fourth waveguide in the second switch position.
7. The optical switching system of claim 1, wherein the first bi-stable mirror has a first rotational axis and the second bi-stable mirror has a second rotational axis parallel to the first rotational axis.
8. The optical switching system of claim 7, wherein the first bi-stable mirror pivots on the first rotational axis in a first direction and the second bi-stable mirror pivots on the second rotational axis in a second direction opposite the first direction.
9. The optical switching system of claim 8, wherein the first and second bi-stable mirrors comprise electrostatic comb actuators.

10. The optical switching system of claim 1, wherein the first bi-stable mirror assumes a first angle in the first switch position and assumes a second angle in the second switch position.
11. The optical switching system of claim 10, wherein at least one of the first and second angles is mechanically defined.
12. The optical switching system of claim 10, wherein at least one of the first and second angles is defined by an electric field.
13. The optical switching system of claim 1, further comprising:
 - a. a first photodetector monitoring a first beam intensity in the third waveguide and producing a first feedback signal in response to the first beam intensity; and
 - b. a second photodetector monitoring a second beam intensity in the fourth waveguide and producing a second feedback signal in response to the second beam intensity.
14. The optical switching system of claim 13, further comprising control electronics connected to the first and second photodetectors and receiving the first and second feedback signals.
15. The optical switching system of claim 14, wherein the control electronics issues control signals to the first

and second bi-stable mirror in response to the first and second feedback signals.

16. The optical switching system of claim 1, wherein at least one of the first, second, third, and fourth waveguides are optical fibers.
17. The optical switching system of claim 1, wherein at least one of the first and second bi-stable mirrors includes an electrostatic actuator.
18. The optical switching system of claim 17, wherein the actuator actuates in only one direction.
19. The optical switching system of claim 17, wherein the actuator includes a comb.
20. An electrostatic actuator comprising:
 - a. an actuated member;
 - b. a first comb extending from the actuated member, the first comb including a first plurality of comb teeth having a first plurality of interconnected tooth ends and a second plurality of interconnected tooth ends;
 - c. a second comb including a second plurality of comb teeth interdigitated to an extent with the first plurality of comb teeth; and
 - d. a voltage source applying a bias voltage between the first and second combs;
 - e. wherein increasing the bias voltage increases the extent to which the first and second pluralities of comb teeth are interdigitated.

21. The actuator of claim 20, the first comb including a frame, and wherein the frame interconnects the second plurality of interconnected tooth end.
22. The actuator of claim 20, wherein the actuated member comprises a mirror.
23. The actuator of claim 20, wherein the actuated member pivots on an axis of rotation.
24. The actuator of claim 23, wherein the actuated member has a center of gravity, and wherein the axis of rotation intersects the center of gravity.
25. The actuator of claim 24, wherein the first plurality of teeth do not extend across the axis of rotation.
26. The actuator of claim 20, wherein the actuator is part of a variable optical attenuator.
27. The actuator of claim 20, wherein the actuator is part of a one-by-n switch.
28. The actuator of claim 27, wherein the switch includes a collimator having n fibers.
29. The actuator of claim 28, wherein the fibers are focused using at least one focusing element selected from the group consisting of a single lens common to multiple ones of the n fibers, grin fibers, fiber lenses, discrete lenses, and lens arrays.

30. An actuator comprising:
- a. a first electrical contact connected to a first voltage source;
 - b. a second electrical contact connected to a second voltage source;
 - c. a first conductive layer connected to the first voltage source via the first electrical contact;
 - d. a second conductive layer connected to the second voltage source via the second electrical contact; and
 - e. an insulating layer of an insulating-layer thickness disposed between the first and second conductive layers;
 - f. wherein a portion of the first conductive layer approaches the second conductive layer in response to a voltage potential applied between the first and second electrical contacts; and
 - g. wherein the insulating layer forms a ledge separating the first and second conductive layers by a surface conduction path greater than the insulating layer thickness.
31. The actuator of claim 30, wherein the first conductive layer includes a first comb having a first plurality of teeth and the second conductive layer includes a second comb having a second plurality of teeth, and wherein the first and second pluralities of teeth are interdigitated from a perspective normal to the first conductive layer.
32. The actuator of claim 30, further comprising a mirror surface disposed on the first conductive layer.

33. The actuator of claim 32, further comprising an input fiber directing a light beam at the mirror surface to produce a reflected beam and an output fiber receiving at least a portion of the reflected beam, wherein the portion is of an intensity determined by the applied voltage potential.
34. The actuator of claim 33, further comprising a second output fiber, wherein the mirror surface directs the reflected beam to the second output fiber in response to a second applied voltage potential.
35. The actuator of claim 30, wherein the first conductive layer is patterned using an etch process, and wherein the etch process etches through a first portion of the first conductive layer at a first etch rate and etches through a second portion of the first conductive layer at a second etch rate slower than the first etch rate.
36. The actuator of claim 30, wherein the actuator is part of a variable optical attenuator.
37. The actuator of claim 30, wherein the actuator is part of a one-by-n switch.
38. The actuator of claim 37, wherein the switch includes a collimator having n fibers.
39. The actuator of claim 38, wherein the fibers are focused using at least one focusing element selected from the group consisting of a single lens common to multiple ones

of the n fibers, grin fibers, fiber lenses, discrete lenses, and lens arrays.

40. An actuator comprising:

- a. a substrate;
- b. an actuated member connected to the substrate and having a rotational axis parallel to the substrate;
- c. first and second movable combs extending from the actuated member on either side of the rotational axis from a perspective normal to the substrate;
- d. first and second fixed combs connected to the substrate, wherein the first and second fixed combs are on opposite sides of the rotational axis from the perspective normal to the substrate; and
- e. a hinge connecting the movable combs to the substrate, the hinge having a hinge thickness in a dimension normal to the substrate and a hinge width in a dimension parallel to the substrate, wherein the hinge thickness is less than the hinge width.

41. The actuator of claim 40, wherein the actuated member comprises a mirror surface.

42. The actuator of claim 40, wherein the actuator is part of a variable optical attenuator.

43. The actuator of claim 40, wherein the movable combs have a comb thickness in the dimension normal to the substrate, and wherein the comb thickness is greater than the hinge thickness.

44. The actuator of claim 40 wherein the actuator is part of a one-by-n switch.
45. The actuator of claim 44, wherein the switch includes a collimator having n fibers.
46. The actuator of claim 45, wherein the fibers are focused using a focusing element selected from the group consisting of a single lens common to multiple one of the n fibers, grin fibers, fiber lenses, discrete lenses, and lens arrays.